Inherent Optical Properties in the Benthic Environment

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LONG-TERM GOALS

The long term goals of this effort are to delineate the small scale structure of the inherent optical properties (IOP) in the benthic environment and to investigate how small scale variations in the IOP affect radiative transfer and visibility in the benthic environment.

SCIENTIFIC OBJECTIVES

The primary objective this year was to determine the small scale temporal and spatial variability of the Inherent Optical Properties (IOP) during the CoBOP field experiment using a diver operated ac-9 and to identify sources and sinks of variability.

APPROACH

We participated in the Coastal Benthic Optical Properties (CoBOP) experiment at Lee Stocking Island, the Bahamas, from May 22nd to June 3rd 1999. Our approach is to use the diver operated spectral absorption and attenuation meter (ac-9) developed by us in collaboration with Western Environmental Technology Laboratories (WET Labs). This device was used to measure these coefficients on small scales within coral reefs, seagrass beds and other benthic environments. In addition, this year we used a sampling package deployed from a small boat which included a SeaBird CTD and an ac-9 to determine either temporal or spatial distribution of IOP on scales of 10-1000m/0.1-2hrs and their relation to the hydrographic properties at chosen sites. The package was loaned to other groups (Dr's Reid, Zimmerman, Phillpot) during over-flights of the Phills sensor for validation and for matchup with data collected by these PI's with HTSRB.

In order to insure calibration we brought along a Barnstead water purifier. The IOP measured were the spectral absorption and attenuation coefficients, with the spectral scattering coefficient obtained as a

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derived parameter. A 0.2μ pre-filter was used at times to distinguish between IOP of the dissolved and particulate fractions. Comparison with spectra measured with Dr Zimmerman's bench-top spectrophotometer provided an independent confirmation of the high quality of our data. Data were collected and stored via an enclosed data-logger. The underwater package also contained a battery pack and pump. Water was sucked into the ac-9 via a tube held by the diver. Wavelengths used were 412, 440, 488, 510, 532, 555, 650, 676, and 715 nm. A second diver used a video camera to record the diver with the ac-9 package and/or log the details of the dive.

Two sampling modes were employed. In the first a vertical profile of approximately 3m were taken at a specific location (along a pole with 10cm marks). In the second mode we carried out transects at certain distances (typically 50, 100, and 200 cm) above the bottom.

Towards the middle of the experiment we have identified a possible source/sink for CDOM; sediment pore waters. In order to determine the gradients between sediments and pore water we modified the diver package to include a rigid wand with a coarse pre-filter (to keep most particles away from the filter). This wand was inserted into the bottom substrate to sample the IOP of pore waters. The use of real time readout was invaluable in determining the presence/absence of bubbles/particles within the ac-9 and make sure the signal has stabilized.

WORK COMPLETED

Our participation in the CoBOP experiment was successful.The following table summerize the measurement we have obtained:

Type of measurement	number of measurements	Locations
Diver package:		
Horizontal section (total IOP)	20	Bank, NP, HS, RG, CM
Horizontal section (dissolved IOP)	20	Bank, NP, HS, RG, CM
Vertical profiles (total IOP)	17	Bank, NP, HS, RG, CM
Vertical profiles (dissolved IOP)	16	Bank, NP, HS, RG, CM
Pore water CDOM measurements (CM):		
Ooids	2	
Sparse grass	5	
Dense grass	5	
CTD package:		
Time series (total IOP)	9	CM, GS, RG
Horizontal sections (total IOP)	6	Bank, NP, CM, GS
Horizontal sections (dissolvedl IOP)	1	CM, GS
Vertical profile (Toal IOP)	1	NP

NP-north Perry, HS-Horseshoe, RG-rainbow garden, CM-Channel marker, GS-grapestone.

In addition, the data from field year 1998 was processed and posted on CoBOP web site maintained by USF.

RESULTS

Total absorption was found to be dominated by CDOM for λ <550nm while dominated by water for λ>550nm. Variability in absorption, however, is dominated by the particulate fraction. Total attenuation was dominated by scattering off particles at all wavelengths. Chlorophyll absorption was found to be small ($a_p(676)$- $a_p(650)<0.015$ m^{-1}), though not a negligible part of particulate absorption.

Figure 1 shows transects at Horseshoe Reef. These transects were taken at three different depths above the bottom. It was found that the beam attenuation coefficient had a similar median value at all depth, but was most variable closer to the bottom. This indicates the intense patchiness in attenuation occurring closer to the bottom, probably due to biological activity.

We found that there are no appreciable vertical gradients in IOP over the banks and at Adderly cut. Small, but significant vertical gradients in IOP where found at N. Perry and Horseshoe reefs (Fig. 2). These data are often consistent with the hypothesis that coral reefs are sinks of particulate material (grazing) and sources of CDOM (exudation).

To our knowledge, we have preformed the first in-situ pore water CDOM spectrum measurement. Our data agree well with the trends in DOC concentrations measured in the lab on collocated samples collected by Dr. Burdige. These data (e.g. Fig. 3) support the hypothesis that decomposition of organic material in grass beds increases the organic content of the sediment and is a source of CDOM to the water column. Tidal fluctuation can change the direction of CDOM flux from the water into the sediment or vice versa. Thus, disturbance of sediment during high-energy events may cause noticeable changes in the CDOM content of the overlying waters.

Based on the CTD package measurement we found the waterfall in Norman Kay to be a source for CDOM; CDOM absorption at Grapestone was twice the value elsewhere on the banks. Temporal gradients in attenuation were as high as $0.05m^{-1}$/10min and horizontal gradients as high as $0.1m^{-1}$/500m near grapestone. Elsewhere gradients were smaller. In general the gradients depended on the tidal phase.

IMPACT/APPLICATIONS

We have determined small scale horizontal variability of IOP in the benthic environment which will enable us to test the plane parallel assumption often used in radiative transfer. We have pioneered a new method of measuring pore-water CDOM absorption in-situ.

TRANSITIONS

Our data are being used by Drs. Philpot, Mobley, Reid, Maffione, Zimmerman and Lesser as inputs into radiative transfer models. Dr Burdige uses our pore-water CDOM measurement for comparison with his laboratory measurements of DOC.

RELATED PROJECTS

None

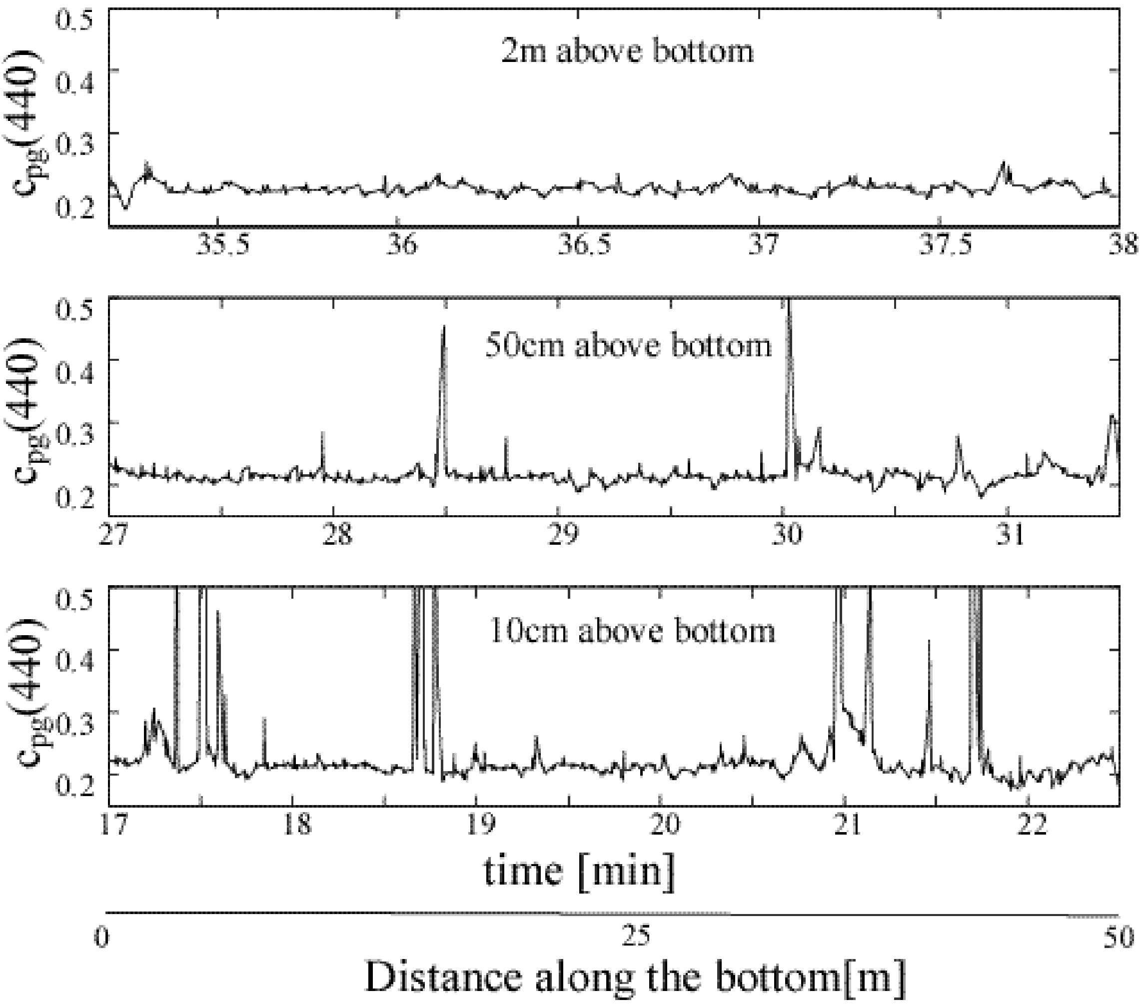

Figure 1. Total attenuation at 440nm at different vertical distances from a reef (Horseshoe coral reef). Notice the decrease in variability with distance.

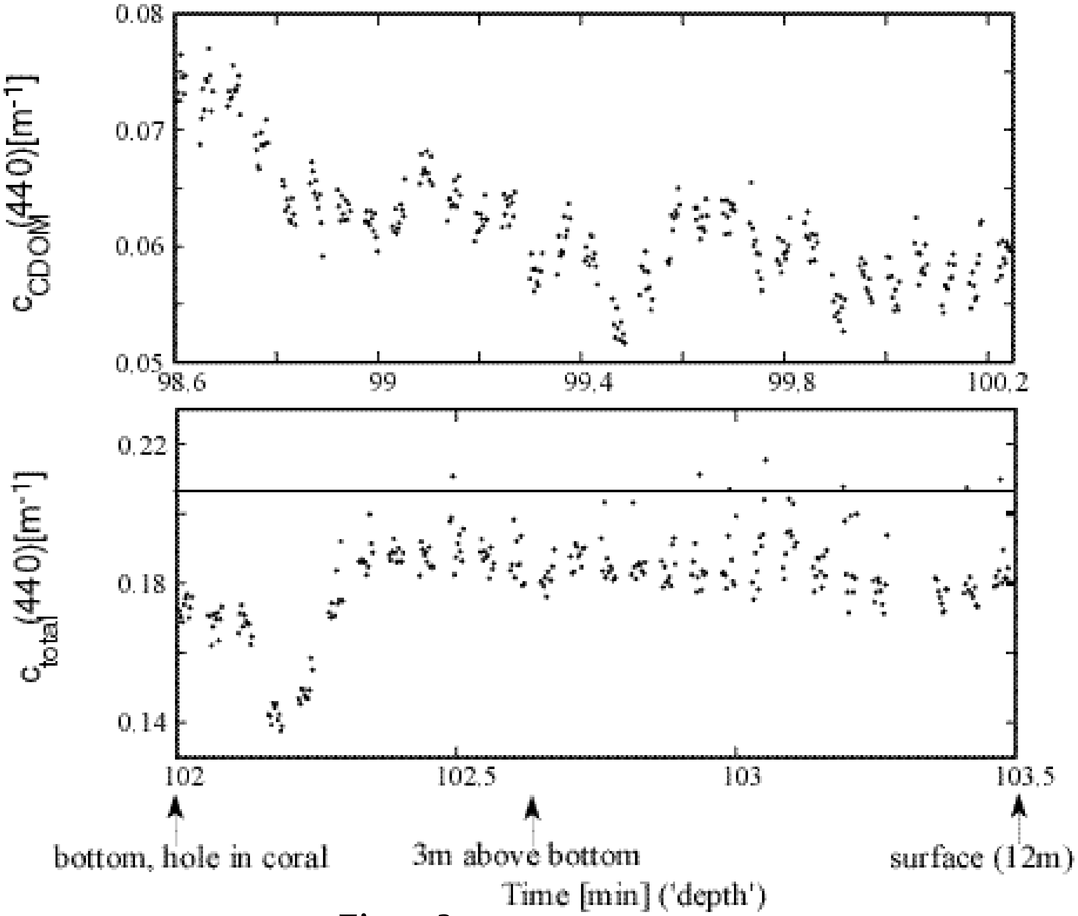

Figure 2.

Vertical profiles of attenuation by CDOM (top) and total attenuation (bottom) at 440nm above the Horseshoe coral reef. These data support the hypothesis that corals are sinks of particulate and sources of CDOM.

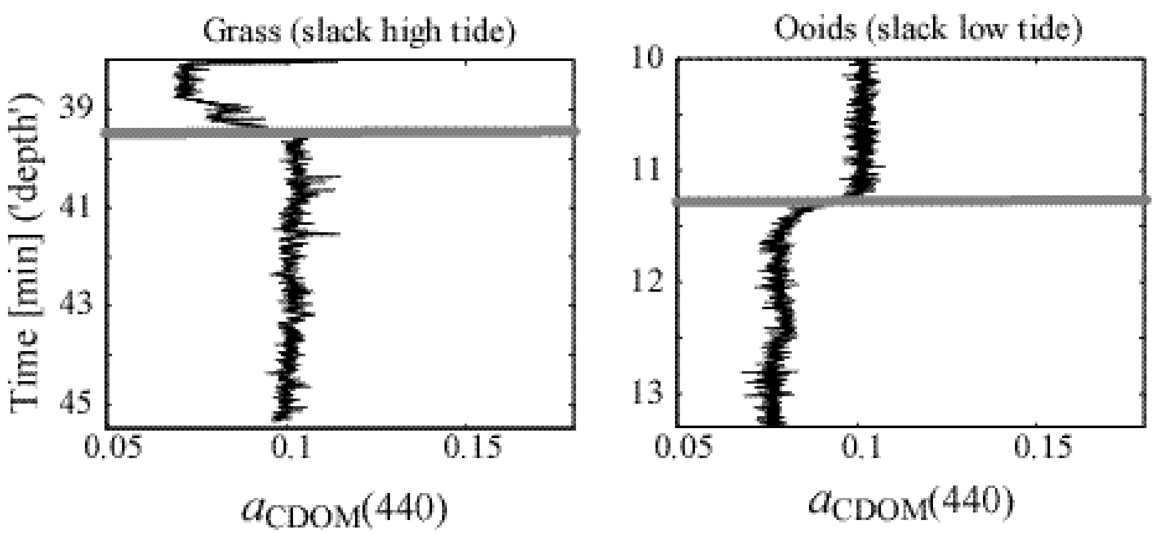

Figure 3. Vertical profiles CDOM absorption (440nm) in dense grass (A) and ooids sediments (B) at channel marker. Gray line denotes the water sediment interface.